MECHANISM AND MACHINE THEORY

Dynamics of Machine Systems
Gears and Power Transmissions
Robots and Manipulator Systems
Computer-aided Design Methods

List of Contents and Author Index
Volume 26, 1991

PERGAMON PRESS
OXFORD • NEW YORK • SEOUL • TOKYO

MECHANISM AND MACHINE THEORY

The scientific journal of IFToMM

The International Federation for the Theory of Machines and Mechanisms

EDITOR-IN-CHIEF

Professor T. E. Shoup
Dean of Engineering and Sobrato Professor of Engineering, Santa Clara University,
Santa Clara, CA 95053, USA

EDITORS

Herausgeber für alle Beiträge in deutscher Sprache:

Professor Dr-Ing.habil. J. Volmer
Technische Universität, Postfach 964, D 09010 Chemnitz, Fed. Rep. Germany

Rédacteur pour toutes les oeuvres écrites en langue française:

Dr L. Cloutier
Faculty of Science and Engineering, Université Laval, Québec, Canada G1K 7P4

Russian language editor:

Professor P. A. Lebedev
Postbox 16, 199178 Leningrad, USSR

Editor for book reviews, IFToMM newssheets and feature articles:

Professor A. Midha
School of Mechanical Engineering, Purdue University,
308 Mechanical Engineering Building, West Lafayette,
IN 47907, USA

Editor for papers on dynamics of machine systems:

Professor J. P. Sadler
Department of Mechanical Engineering, University of Kentucky,
Lexington, KY 40506-0046, USA

Editor for papers on manipulators, robotics and man–machine systems:

Dr E. Heer
5329 Crown Avenue, La Canada, CA 91011, USA

Editor for papers on computer-aided design and optimization:

Professor D. Riley
Department of Mechanical Engineering, University of Minnesota,
111 Church Street S. E., Minneapolis, MN 55455, USA

EDITOR EMERITUS

Professor F. R. E. Crossley, Bradford, Conn., USA

ASSOCIATE EDITORS

Professor B. Roth, Stanford, Calif., USA
Professor A. T. Yang, Davis, Calif., USA

HONORARY EDITORIAL ADVISORY BOARD

Dr R. S. Berkof, Swarthmore, Pa, USA
Professor G. Bianchi, Milan, Italy
Professor Dr O. Bottema, Delft, The Netherlands
Dr S. Deutsch, Washington, D.C., USA
Professor Dr-Ing. B. Dizioğlu, Braunschweig, Fed. Rep. Germany
Professor S. Dubowsky, Cambridge, Mass., USA
Professor A. G. Erdman, Minneapolis, Minn., USA
Professor F. Freudenstein, New York, N.Y., USA
Dr-Ing. K. Hain, Braunschweig, Fed. Rep. Germany
Professor R. S. Hartenberg, Evanston, Ill., USA
Professor K. H. Hunt, Clayton, Victoria, Australia
Dr J. Ishikawa, Yokohama, Japan
Professor I. Kato, Tokyo, Japan
Professor Dr F. L. Litvin, Chicago, Ill., USA
Professor Dr D. J. Mangeron, Iasi, Romania
Professor Dr N. I. Manolescu, Bucharest, Romania
Professor L. Maunder, Newcastle upon Tyne, England
Mr S. Mollian, Olney, Bucks., England
Professor Dr A. Morecki, Warsaw, Poland
Professor Dr J. Oderfeld, Warsaw, Poland
Dr E. Peizer, New York, N.Y., USA
Professor Jack Phillips, Sydney, Australia
Dr J. M. Prentis, Cambridge, England
Professor J. S. Rao, New Delhi, India
Professor G. N. Sandor, Gainesville, Fla, USA
Professor D. S. Tavkhelidze, Tbilisi, Georgia, USSR
Dr M. A. Tolcott, Arlington, Va, USA
Professor R. Tomović, Belgrade, Yugoslavia
Professor John J. Uicker Jr, Madison, Wis., USA
Professor H. J. Warnecke, Stuttgart, Fed. Rep. Germany
Mr E. J. Wellauer, Milwaukee, Wis., USA
Professor Dr W. Wunderlich, Vienna, Austria
Professor G. V. Tordion, Québec, Canada

IFToMM EXECUTIVE COUNCIL

President:	**Professor G. Bianchi,** Italy
Vice-President:	**Professor G. Bögelsack,** Fed. Rep. Germany
Secretary General:	**Dr L. Půst,** CSSR
Treasurer:	**Dr J. N. Fawcett,** England
Councillors:	**Professor G. Dittrich,** Fed. Rep. Germany
	Professor K. V. Frolov, USSR
	Professor T. Hayashi, Japan
	Professor J. S. Rao, India
	Professor A. Seireg, USA
	Professor J. Nieto, Spain

Past-President (ex off.) **Professor B. Roth,** USA

Publishing Office: Pergamon Press plc, Pergamon House, Bampfylde Street, Exeter EX1 2AH, England [*Tel.* Exeter (0392) 51558; *Fax* 425370].

Subscription and Advertising Offices: *North America:* Pergamon Press Inc., 395 Saw Mill River Road, Elmsford, NY 10523, USA. *Rest of the world:* Pergamon Press plc, Headington Hill Hall, Oxford OX3 0BW, England [*Tel.* (0865) 794141; *Fax* 60285].

Publication Frequency: 7 issues/annum

Subscription Rates: Annual institutional subscription rate (1992): £350.00 (US$560.00). Two-year institutional rate (1992/93): £655.00 (US$1064.00). Sterling prices are definitive. US dollar prices are quoted for convenience only, and are subject to exchange rate fluctuation. Prices include postage and insurance and are subject to change without notice. Subscription rates for Japan are available on request. Members of the U.S. Council for the Theory of Machines and Mechanisms may order personal subscriptions at a concessional rate.

Back Issues: Back issues of all previously published volumes, in both hard copy and on microform, are available direct from Pergamon Press offices.

Copyright © 1991 Pergamon Press plc

It is a condition of publication that manuscripts submitted to this journal have not been published and will not be simultaneously submitted or published elsewhere. By submitting a manuscript, the authors agree that the copyright for their article is transferred to the publisher if and when the article is accepted for publication. However, assignment of copyright is not required from authors who work for organizations which do not permit such assignment. The copyright covers the exclusive rights to reproduce and distribute the article, including reprints, photographic reproductions, microform or any other reproductions of similar nature and translations. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, electrostatic, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing from the copyright holder.

Whilst every effort is made by the publishers and editorial board to see that no inaccurate or misleading data, opinion or statement appears in this journal, they wish to make it clear that the data and opinions appearing in the articles and advertisements herein are the sole responsibility of the contributor or advertiser concerned. Accordingly, the publishers, the editorial board and editors and their respective employees, officers and agents accept no responsibility or liability whatsoever for the consequences of any such inaccurate or misleading data, opinion or statement.

Photocopying information for users in the USA
The Item-fee Code for this publication indicates that authorization to photocopy items for internal or personal use is granted by the copyright holder for libraries and other users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service provided the stated fee for copying beyond that permitted by Section 107 or 108 of the United States Copyright Law is paid. The appropriate remittance of $3.00 per copy per article is paid directly to the Copyright Clearance Center Inc., 27 Congress Street, Salem, MA 01970, USA. The copyright owner's consent does not extend to copying for general distribution for promotion, for creating new works, or for resale. Specific written permission must be obtained from the publisher for such copying.
The Item-fee Code for this publication is: 0094-114X/91 $3.00 + 0.00.

♾™ The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48-1984.

List of Contents

NUMBER 1

J. Eddie Baker	1	The group of generalized star-point eight-bar plane linkages
J. M. Prentis	19	The pole triangle, Burmester theory and order and branching problems—I. The order problem
J. M. Prentis	31	The pole triangle, Burmester theory and order and branching problems—II. The branching problem
J. Kieffer and **F. L. Litvin**	41	Local parametric representation of displacement functions for linkages and manipulators
A. C. Rao and **D. Varada Raju**	55	Application of the Hamming number technique to detect isomorphism among kinematic chains and inversions
Jean-Pierre Merlet et **Clément Gosselin**	77	Nouvelle architecture pour un manipulateur parallèle à six degrés de liberté
Charles Wampler and **Alexander Morgan**	91	Solving the 6*R* inverse position problem using a generic-case solution methodology
P. Minotti	107	Découplage dynamique des manipulateurs: propositions de solutions mécaniques
Software Survey Section	I	
New Patents	V	

NUMBER 2

B. Weyh and **H. Kostyra**	123	Direct Floquet method for stability limits determination—I. Theory
H. Kostyra and **B. Weyh**	133	Direct Floquet method for stability limits determination—II. Application and phenomena
Chung-Biau Tsay and **Z. H. Fong**	145	Computer simulation and stress analysis of helical gears with pinion circular arc teeth and gear involute teeth
G. J. Walsh, D. A. Streit and **B. J. Gilmore**	155	Spatial spring equilibrator theory
Adel K. Al-Sabeeh	171	Irregular gears for cyclic speed variation
D. McCloy	185	The power consumption of mechanical legs

Gao Feng 197 Complete shaking force and shaking moment balancing of 17 types of eight-bar linkages only with revolute pairs

K. Kim and **M. K. Kim** 207 Volumetric accuracy analysis based on generalized geometric error model in multi-axis machine tools

Mirosław Galicki 221 A closed solution to the inverse kinematics of redundant manipulators

M. O. M. Osman, B. M. Bahgat and **R. V. Dukkipati** 227 Kinematic analysis of robot's manipulators using consecutive analysis of train components

Book Review
T. E. Shoup 237 Design of Devices and Systems, 2nd edn. By William H. Middendorf

Software Survey Section I

New Patents V

NUMBER 3

F. W. Liou, Arthur G. Erdman and **C. S. Lin** 239 Dynamic analysis of a motor-gear-mechanism system

L. J. Cveticanin 253 The oscillations of a textile machine rotor on which the textile is wound up

M. T. Pietola and **M. J. Vilenius** 261 Sensitivity of a position servo system to variations in the constructive parameters in transient and steady state

I. S. Kochev 275 Contribution to the theory of torque, shaking force and shaking moment balancing of planar linkages

I. S. Kochev 285 Optimum balancing of a class of multiloop linkages by function cognate transformations

Parveen Kalra and **Anand M. Sharan** 299 Accurate modelling of flexible manipulators using finite element analysis

Jorge Angeles 315 Die theoretischen Grundlagen zur Behandlung algebraischer Singularitäten der kinematischen Koordinatenumkehr in der Robotertechnik

B. Benhabib, E. Tabarah, R. Cohen and **R. G. Fenton** 323 Robot performance optimization under specified dynamic conditions

Niu Ming Qi and **E. Pennestrí** 337 Optimum balancing of four-bar linkages. A refined algorithm

Book Reviews

T. E. Shoup 349 Machine Learning—Paradigms and Methods. Edited by Jaime Carbonell

L. A. Sanchez 349 Introduction to Theoretical Kinematics. By J. M. McCarthy

Software Survey Section I

New Patents V

NUMBER 4

Hyunsoo Kim, Hyoweon Ahn and **Kurt M. Marshek** 351 Friction characteristics for concentrated load area in a flat belt drive

Stelios C. A. Thomopoulos and **Ricky Y. J. Tam** 359 An iterative solution to the inverse kinematics of robotic manipulators

Ray P. S. Han, M. A. Thomlinson and **Y. S. Tu** 375 Kinematics and kinetics of a non-circular bicycle drive system

T. M. Abdel-Rahman and **M. A. Elbestawi** 389 Synthesis and dynamics of statically balanced direct-drive manipulators with decoupled inertia tensors

M. Giordano 403 Analyse géométrique des mécanismes à l'aide d'angles d'Euler duaux

Harry H. Denman 415 Exact solution for the rigid slider-crank mechanism with gas pressure

S. Turgut Tümer and **Y. Samim Ünlüsoy** 421 Nondimensional analysis of jump phenomenon in force-closed cam mechanisms

Book Reviews

E. J. Fisher 433 Computer-assisted Mechanical Design (1st edn). By J. Ed Akin

T. G. Yip 433 Packaging of Electronic Systems—A Mechanical Engineering Approach. By James W. Dally

T. E. Shoup 434 Proceedings of the Xth IFAC World Congress, Munich, F.R.G., 27–31 July, 1987. Edited by R. Isermann

Software Survey Section I

New Patents V

NUMBER 5

TERMINOLOGY FOR THE THEORY OF MACHINES AND MECHANISMS

TERMINOLOGIE POUR LA THEORIE DES MACHINES ET DES MECANISMES

TERMINOLOGIE FÜR DIE THEORIE DER MASCHINEN UND MECHANISMEN

ТЕРМИНОЛОГИЯ ПО ТЕОРИИ МАШИН И МЕХАНИЗМОВ

Preface vii
IFToMM Commission A ix

1. STRUCTURE OF MACHINES AND MECHANISMS
STRUCTURE DES MACHINES ET MECANISMES
STRUKTUR VON MASCHINEN UND MECHANISMEN
СТРУКТУРА МАШИН И МЕХАНИЗМОВ

1.1 Components 436
Composants
Bauelemente
Компоненты

1.2 Sub-assemblies 444
Sous-ensembles mécaniques
Baugruppen
Сборные узлы

1.3 Mechanisms 448
Mécanismes
Mechanismen und Getriebe
Механизмы

2. KINEMATICS
CINEMATIQUE
KINEMATIK
КИНЕМАТИКА

2.1 General 456
Généralités
Allgemeines
Общие термины

2.2 Motion (Quantities, States) 456
Mouvement (Grandeurs, Etats)
Bewegung (Größen, Zustände)
Движение (Величины, состояния)

2.3 Kinematic geometry 464
Géométrie cinématique
Bewegungsgeometrie
Кинематическая геометрия

3. DYNAMICS
DYNAMIQUE
DYNAMIK
ДИНАМИКА

3.1 General 470
Généralités
Allgemeines
Общие понятия

3.2 Force and moment 470
Force et moment
Kraft und Moment
Сила и момент

3.3 Momentum, energy, work and power 480
Quantité de mouvement, énergie, travail et puissance
Impuls, Energie, Arbeit und Leistung
Количество движения, энергия, работа и мощность

3.4 Principles 484
Principes
Prinzipien
Принципы

3.5 Structural behaviour and characteristics 486
Caractéristiques du comportement des structures
Strukturelle Eigenschaften und Merkmale
Структурные позедение и характеристики

3.6 Structural concepts 496
Concepts de structure
Strukturelle Konzepte
Структурные концепции

3.7 Dynamical concepts 498
Concepts dynamiques
Dynamische Konzepte
Динамические концепции

3.8 Dynamical systems and characteristics 506
Systèmes dynamiques et caractéristiques
Dynamische Systeme und Charakteristika
Динамические системы и характеристики

3.9 Vibrations 508
Vibrations
Schwingungen
Колебания

4. MACHINE CONTROL AND MEASUREMENTS
COMMANDE DE SYSTEMES ET MESURES
STEUERUNG VON MASCHINEN UND MESSTECHNIK
УПРАВЛЕНИЕ МАШИН И ИЗМЕРЕНИЯ

4.1 Signals and Functions — **516**
Signaux et Fonctions
Signale und Funktionen
Сигналы функциональных назначений

4.2 Accuracy and Errors — **520**
Exactitude et Erreurs
Genauigkeit und Fehler
Точность и погрешность

4.3 Devices and Components — **524**
Dispositifs et Composants
Ausrüstungen und Baulemente
Устройства и компоненты

5. ROBOTICS
ROBOTIQUE
ROBOTERTECHNIK
РОБОТОТЕХНИКА

5.1 Systems — **526**
Systèmes
Systeme
Системы

5.2 Components — **528**
Constituants
Baugruppen
Компоненты

5.3 Motion — **530**
Mouvement
Bewegung
Движение

5.4 Control — **534**
Commande
Steuerung
Системы

5.5 Miscellaneous — **534**
Divers
Verschiedenes
Разное

A. APPENDIX: GENERAL TERMS USED IN TMM — 536
APPENDIX: TERMES GENERAUX UTILISES EN TMM
ANHANG: IN DER TMM HÄUFIG GEBRAUCHTE ALLGEMEINE BEGRIFFE
ПРИЛОЖЕНИЕ: ОБЩИЕ ТЕРМИНЫ ИСПОЛЬЗУЕМЫЕ В ТММ

INDEX—ENGLISH — I
INDEX—FRANÇAIS — XIV
REGISTER — XXVII
АЛФАВИТНЫЙ УКАЗАТЕЛЬ ТЕРМИНОВ — XXXIV

Reproduced with the permission of Pergamon Press Inc., by University Microfilms Inc. Duplication or resale without permission is prohibited.